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IS 12193 (Part 1) : 1989

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Indian Standard

METHODS OF MEASUREMENT ON RADIO RECEIVERS FOR VARIOUS CLASSES OF EMISSION

PART 1 GENERAL CONSIDERATIONS AND METHODS OF MEASUREMENT INCLUDING AUDIO-FREQUENCY MEASUREMENTS

भारतीय मानक

विभिन्न उत्सर्जन वर्गों के लिए रेडियो रिसीवरों की मापन पद्धतियाँ

भाग 1 सामान्य विचारणीय तथ्य और मापन पद्धतियाँ, श्रव्य आवृति मापन सहित

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Indian Standard

METHODS OF MEASUREMENT ON RADIO RECEIVERS FOR VARIOUS CLASSES OF EMISSION

PART 1 GENERAL CONSIDERATIONS AND METHODS OF MEASUREMENT INCLUDING AUDIO-FREQUENCY MEASUREMENTS

1 SCOPE

1.1 This standard (Part 1) applies to radio receivers of any kind, excluding television receivers, and to the parts of which they are composed or which are used as auxiliaries to such receivers.

1.2 This standard covers both mains-operated and battery-operated receivers.

2 REFERENCES

2.1 The Indian Standard listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.0 For the purpose of this standard the definitions given in IS 1885 (Part 22) : 1967 and IS 1885 (Part 24) : 1967 shall apply.

SECTION 1 GENERAL

4 FREQUENCIES OF MEASUREMENT

4.1 Audio Frequencies

If measurements are to be made at discrete frequencies, then these shall be the frequencies specified as preferred frequencies for acoustical measurements as given in Table 1. If a measurement relates to a reference audio-frequency, this shall be the standard reference frequency of 1 000 Hz. If a measurement is to be made using

Table 1 Preferred Frequencies for Acoustical Measurement (Hz)

(*Clause* **4.1**)

Preferred Frequencies	1/1 Octave	1/2 Octave	1/3 Octave	Preferred Frequencies	1/1 Octave	1/2 Octave	1/3 Octave	Preferred Frequencies	1/1 Octave	1/2 Octave	1/3 Octave
16	×	×	×	160			×	1 600			×
18				180		×		1 800			
20			×	200			×	2 000	×	×	×
22·4		×		224				2 240			
25			×	250	×	×	×	2 500			×
28				280				2 800		×	
31·5	×	×	×	315			×	3 150			×
35·5				355		×		3 550			
40			×	400			×	4 000	×	×	×
45		×		450				4 500			
50			×	500	×	×	×	5 000			×
56				560				5 600		×	
63	×	×	×	630			×	6 300			×
71				710		×		7 100			
80			×	800			×	8 000	×	×	×
90		×		900				9 000			
100			×	1 000	×	×	×	10 000			×
112				1 120				11 200		×	
125	×	×	×	1 250			×	12 500			×
140				1 400		×		14 000			
160			×	1 600			×	16 000	×	×	×

NOTES

1 The table may be extended in either direction by successive multiplication or division by 1 000.

2 The sign × indicates in each column the geometric mean frequencies of the filters mentioned in **7**.

3 The exact preferred frequencies calculated from $1\,000 \times 10^{3n/10}$ for octave band filters, $1\,000 \times 10^{3n/20}$ for half-octave band filters and $1\,000 \times 10^{n/10}$ for third-octave band filters where *n* is a positive or negative integer, or zero. are to be used for the design of filters rather than the nominal values given in the table.

For normal measurements, the difference between the nominal and the exact frequencies is negligible.

only one signal frequency, the signal frequency shall be the chosen reference frequency. If measurements are to be made at a number of different frequencies, the chosen reference frequency shall be included, the other frequencies being so chosen that the results of the measurements give an adequate representation of the behaviour of the characteristics over the whole of the effective frequency range.

If measurements are to be made in frequency bands of constant relative band-width, preference shall be given to one octave and one-third octave bands mentioned in **7.1**.

4.2 Radio Frequencies

4.2.1 *General*

Where applicable, frequencies shall be chosen which are decimal multiples of those given in Table 1. For some purposes, it is necessary to use other frequencies, such as the intermediate frequency of the receiver, and frequencies at which spurious responses or other phenomena occur.

4.2.2 *Measurements on Receivers with Restricted Tuning Range*

Measurements at, or near, the extremes of the tuning range together with one or more frequencies in the middle of the range are normally adequate.

5 QUANTITIES TO BE SPECIFIED AND THEIR ACCURACY

5.1 Unless otherwise stated, the term 'voltage', 'current', etc, mentioned in this standard refer to rms quantities. For most purposes it is sufficient to measure electrical quantities with an accuracy of ± 0·15 dB. The accuracy of measurement required depend only on the purpose for which the results are to be used.

6 MARKING AND SYMBOLS FOR MARKING

6.1 Marking

Terminals and controls shall be adequately marked to give information regarding their function, characteristics and polarity.

The marking shall be such that it must be possible to adjust the controls and to identify their positions with sufficient accuracy in connection with the information given in the user instructions.

6.2 Symbols for Marking

Marking shall preferably be composed of letter symbols, signs, numbers and colours, which are intelligible.

7 FILTERS, WEIGHTING CURVES AND METERS FOR NOISE SPECIFICATION AND MEASUREMENT

A specification of noise or signal-to-noise ratio shall refer to noise measured by one of the following methods.

7.1 Wide Band Measurement

The filter shall be a band-pass filter having a frequency response within the limits shown in Fig. 1. A band-pass filter which has a substantially constant transmission factor between 22·4 Hz and 22·4 KHz, decreasing outside this frequency band at the rates specified for octave band filters having mid-band frequencies of 31·5 Hz and 16 000 Hz, has a response falling within the limits of this specification.

NOTE — Care shall be taken when there may be strong signals just above or below the band-limits since in this case the results will depend, to some degree, on the individual frequency response of the filter actually used.

7.2 Weighted Measurements

7.2.1 *Noise (A-Weighting) or Signal-to-Noise (A-Weighting) Ratio*

The filter used shall have A-weighting characteristics with tolerances as specified for sound level measurements in IS 9779 : 1981. The meter shall be a true rms meter as described in the above standard for sound level meters type I; the dynamic characteristics designed 'S' shall be used.

NOTE — A-weighted measurements are particularly appropriate where the noise output from the equipment in the absence of a programme is concerned.

7.2.2 *Noise (Psophometric) or Signal-to-Noise (Psophometric) Ratio*

The filter and meter used shall have the characteristic described in Annex B.

NOTE — Psophometric measurements are particularly appropriate where the disturbing effect of the noise output from the system in the presence of a programme is concerned.

7.2.3 *Octave/Third-Octave Band Measurement*

The filters shall have characteristics as specified for octave or third-octave band filters in IS 6964 : 1973. The meter shall be a true rms meter as described in IS 9779 : 1981 for sound level meters, type I. When measuring in narrow bands, particularly at low frequencies, it is recommended that the instruments should conform dynamically to the characteristics designated 'S' for the sound level meter (*see* IS 9779 : 1981).

8 RATED VALUES

In this standard the word 'rated' is used in a particular sense wherever it is used. it means 'the

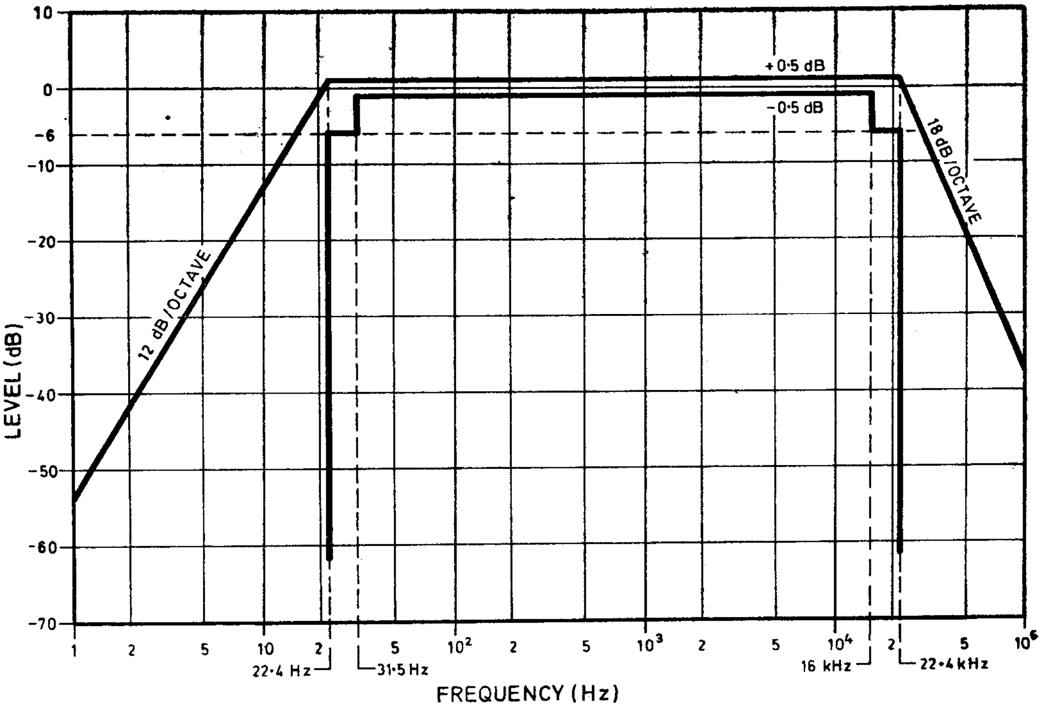


FIG. 1 BANDPASS FILTER FOR WIDE-BAND NOISE MEASUREMENT : AMPLITUDE/FREQUENCY RESPONSE LIMITS

value stated by the manufacturer'. It always has this meaning even though it is used in two different kinds of technical terms which are known as 'rated conditions' and 'rated values of characteristics'.

8.1 Rated Conditions

When an equipment is to be used or tested it has to be operated under certain conditions which are fixed by the manufacturer. These conditions include electrical, mechanical and climatic conditions, and they cannot, by their nature, be verified by measurement.

8.1.1 Rated conditions for a particular type of equipment generally include some or all of the following:

a) Electrical
   1) Rated power supply voltage(s),
   2) Rated power supply frequency,
   3) Rated source impedance(s),
   4) Rated source emf(s) and
   5) Rated load impedance(s);
b) Mechanical
   1) Mounting position and
   2) Ventilation;
c) Climatic
   1) Rated ambient temperature ranges for operation and for full performance to specification,
   2) Rated humidity range and
   3) Rated air pressure range.

NOTE — Ranges are defined by the extreme values, each of which may be regarded as separate rated condition.

8.2 Rated Value of Characteristic

For each of the characteristics to be measured the manufacturer is required or permitted to state a value in the specification of an equipment. This stated value is, by definition, the *rated* value of that characteristic. The application of the term 'rated' in this sense is not restricted to a limited set of major characteristics but may be applied to *any* characteristic for which a method of measurement is given. Since the rated value is the value stated by the manufacturer, the defining title of the 'characteristic to be specified' does *not*, in general, include the word 'rated'; the rated value is not something which is measured but is decided by the manufacturer taking into account measurements on many samples of the equipment and theoretical tolerance calculations. For example, a method of measurement is referred to in this standard and described in another Indian Standard for the distortion limited output power of an amplifier. The rated distortion limited output power is the value stated by the manufacturer, usually calculated from measurements (according to the standard method) on several samples of the amplifier, supplemented by tolerance calculation.

8.3 Interdependent Characteristics

It often happens that the value of one characteristic is required to be stated for a particular value of another characteristic. A prominent example is the noise-limited sensitivity of a receiver, which is stated for a particular value of signal-to-noise ratio.

In such cases it is necessary to adopt one of the characteristics as a rated condition, and it is preferable to adopt that characteristic whose rated value is either specified as a reference value or is chosen by the manufacturer more or less arbitrarily within certain practical limits.

NOTE — Applying the preferred criterion to the above example, the rated signal-to-noise ratio (for which preferred values are given in subsequent parts) is adopted as a rated condition, and the rated noise-limited sensitivity becomes the rated value of characteristic.

8.4 Matching Value

A knowledge of the values of certain basic characteristics of two items of equipment, which are to be connected together, is necessary in order to ensure compatibility. These values are known as matching values and are stated by the manufacturer for conditions defined in the relevant parts of this standard. Some matching values are also rated conditions.

9 CLIMATIC CONDITIONS

9.1 General

Measurements and mechanical checks may be carried out at any combination of temperature, humidity and air pressure within the following limits:

Ambient temperature:	15°C to 35°C
Relative humidity:	45 percent to 75 percent
Air pressure:	860 mbar to 1 060 mbar

For equipment designed to be used in vehicles the ambient temperature limits 5°C to 55°C.

If the manufacturer finds it necessary to specify climatic conditions differing from the above, these shall be chosen from IS : 9000 (Part 1)-1977 and the measurements shall be made under these specified conditions.

The conditions mentioned above represent those under which the equipment is required to meet its specification. Over a wider range the equipment may operate but not meet all of its specifications and it may be permissible to store the equipment under more extreme conditions.

9.2 Referee Conditions

In cases where the characteristics are sensitive to ambient conditions, the following referee conditions shall be maintained during measurements:

Temperature	25 ± 1°C
Relative humidity	65 ± 2 percent
Air pressure	860 to 1 060 mbar

10 INDIVIDUAL SPECIFICATION AND TYPE SPECIFICATION

Values may be specified either for a general type or for an individual sample of this type.

In the first case, the manufacturer shall state whether the specified values are:

a) limits,

b) statistical 'worst case' values (*see* Note), or

c) average values (*see* Note).

NOTE — These values are derived from measurements on a batch and accompanied by the data required to render them significant.

11 GRAPHICAL PRESENTATION OF DATA

11.1 General

The relation between two or more quantities is often more clearly presented as a graph rather than as a table.

When the results of a point-by-point measurement for an individual sample are presented as a continuous curve, the measured points shall be clearly indicated. Extrapolated or intermediate curves based on theoretical expectations or other information presented, but not based on direct measurement, shall be clearly distinguished from measurement curves, for example, by another style of drawing.

Where appropriate, data may be presented as a line or band spectrum of constant bandwidth or constant proportional bandwidth. The bandwidth used shall be stated. Preference shall be given to one octave and one-third octave bands as mentioned in **7.1**

11.2 Scales

Linear or logarithmic scales are recommended for graphical presentation. Other kinds of scales, such as double logarithmic and combinations of linear and logarithmic, shall be avoided. Linear decibel scales are equivalent to logarithmic scales.

Where quantities presented by abscissa and ordinate are of the same kind, the same unit length shall be used for both. A remote zero point in linear scales shall be avoided as far as possible. The zero reference in decibel scale shall, if possible, be the rated value.

For logarithmic frequency scales and polar level diagrams used for presenting the results of audio-frequency measurements, reference is made to IS 8159 : 1976.

11.2.1 *Logarithmic Frequency Scales*

For graphs in which a level (in decibels) is plotted against frequency on a logarithmic scale, the scale proportions shall be those for which the length for a 10 : 1 frequency ratio is equal to the length for a level difference of 50 dB on the ordinate scale.

NOTES

1 The alternative values of level difference (10 dB and 25 dB) given in IS 8159 : 1976 may be used when appropriate.

2 Logarithmic frequency scales are mostly used for plotting modulation frequency rather than carrier frequency.

11.2.2 *Polar Level Diagrams*

For polar plots in which a level in decibels is shown increasing outward along a radius on a linear scale, the maximum level shall preferably be plotted on, or within 2·5 dB of the reference circle whose radius corresponds to a difference in level of 25 dB. The tolerance on the radius of the reference circle corresponds to ± 0·25 dB. These requirements apply for whatever length is chosen to represent 1 dB.

For an absolute level, when the radius of the reference circle corresponds to 25 dB, the level assigned to the reference circle shall be a multiple of 5 dB.

NOTE — If it is necessary to plot a characteristic over a range greater than 25 dB, then a difference in level of 50 dB shall be used.

12 PRECONDITIONING

12.1 General

In order to ensure that when measurements begin, the receiver characteristics do not change significantly with time, the receiver shall be operated under standard measuring conditions for a period of at least 10 minutes (for small battery-operated receivers) and preferably for at least 1 hour (for larger receivers) before recording the results of any measurements.

12.2 Adjustment of Controls

12.2.1 *Tuning*

The receiver is tuned approximately to a desired signal either with the least possible radio-frequency input signal level or with the lowest possible setting of the volume control. The receiver is tuned accurately to a desired signal by first tuning it approximately and then adjusting the tuning controls so that one of the following conditions is satisfied:

a) The receiver is tuned in accordance with manufacturer's instructions, for example, by use of the visual indicator; or

b) The audio-frequency output power is a maximum, provided that the signal is modulated with the standard modulation frequency (400 Hz or 1 000 Hz).

The applied method shall be stated with the results. These tuning positions will not necessarily coincide, and it is desirable to determine and also state the discrepancy between the various methods in terms of the corresponding frequency deviations.

NOTE — The tuning method (b) is generally not applicable to spot-frequency receivers, unless means are provided for manual tuning correction. If this is not the case, the signal generator shall be tuned to the operating frequency of the receiver following the same principles, or for highly stable spot-frequency receivers, to the frequency or frequencies for which the receiver has been designed.

12.2.1.1 For selectivity and electrical frequency characteristic measurements, the following procedure for tuning shall be used.

The receiver shall first be tuned to the signal at standard modulation frequency as specified under **12.2.1**. The modulation frequency shall then be increased until the output power drops to approximately 14 dB or to about 1/25 of the original value, the depth of modulation being kept constant. The tuning controls shall be readjusted until a minimum of output power is obtained, increasing the input signal level, if necessary.

NOTE — In cases where this method of tuning is not applicable, alternative agreed methods may be used.

12.2.2 *'Local-Distant' Switch*

If the receiver has a 'local-distant' switch, this switch shall be set in the 'distant' position for all tests except those in which the receiver is tuned to signals of 0·1 V and more, in which case the switch shall be set to the 'local' position.

12.2.3 *Selectivity Control*

Unless otherwise specified, the selectivity control, if provided, shall be adjusted to maximum band-pass characteristics.

12.2.4 *Tone Control*

Unless otherwise specified, the tone control shall be kept at the position of most uniform response.

12.2.5 *Volume Control*

Unless otherwise specified, the volume control shall be at its maximum position.

13 MEASUREMENTS IN A UNIFORM ALTERNATING LOW-FREQUENCY MAGNETIC FIELD

13.1 Method of Producing a Uniform Alternating Low-Frequency Magnetic Field

A convenient and fairly accurate method of producing a uniform alternating magnetic field makes use of the arrangement of three square coils according to Fig. 2. Dimension $a = 0{\cdot}375\, b$, where a is the distance between the coils and b the dimension of the side of each coil. The coils are supplied with a current at the required frequency.

Between the three coils 1, 2 and 3 having turns in the ratios of $\frac{n1}{100} = \frac{n2}{36} = \frac{n3}{100}$, when the same current I flows through each coil in the same direction, a field is produced that may be considered to be uniform to within ± 2 percent inside a spherical space having a diameter of $d = 0{\cdot}5\, b$, the centre of which coincides with the geometrical centre of coil 2.

The resulting magnetic field strength H and magnetic induction B shall be approximately :

$$H = 1{\cdot}35\, \frac{n1.I}{b}\ \text{A}/m \quad B = 1{\cdot}70\, \frac{n1.I}{b}\ (\ \mu\text{T}\ )$$

The magnetic field strength shall be measured before the sample under test is placed in the magnetic field. This can be done with a search coil (*see* Annex C).

13.2 Positioning the Sample

The sample under test shall be placed in the magnetic field and the position of the sample relative to the pattern of the field shall be varied until the interference is at maximum.

The sample under test shall not project from the spherical space of diameter d.

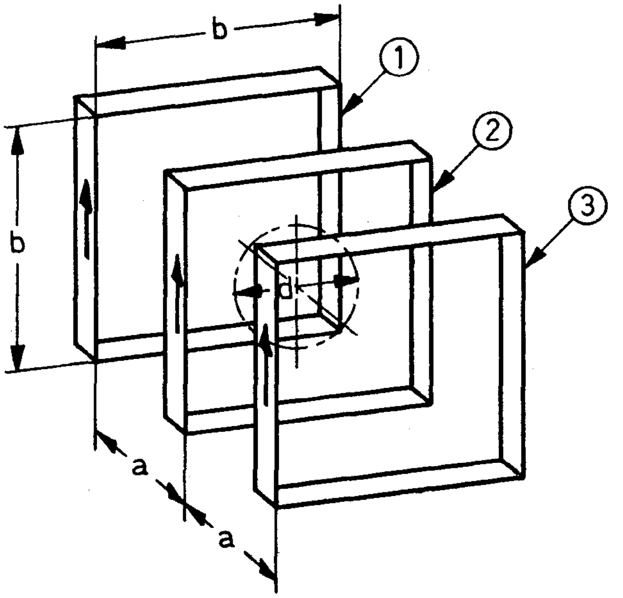
14 TYPES OF POWER SUPPLY AND RELEVANT MEASURING CONDITIONS

The following types of power supply are defined:

Mains : Any centralized ac or dc power source, usually having a rated voltage of more than 24V.

Batteries : Accumulators, primary batteries or any similar energy sources such as solar batteries, thermo-electric cells, etc.

Batteries of the type, voltage and internal resistance, specified for use with the receiver shall be employed; other sources, which essentially simulate the characteristics of those specified may also be used and the substitute arrangements stated with the results.



$a = 0{\cdot}375\, b \qquad d = 0{\cdot}5\, b$

$$\frac{n1}{100} = \frac{n2}{36} = \frac{n3}{100}$$

FIG. 2 ARRANGEMENT OF THREE COILS FOR THE PRODUCTION OF A UNIFORM ALTERNATING MAGNETIC FIELD

Receivers intended for use on more than one type of power supply shall be measured with each type of power supply.

NOTE — In this respect, ac mains and dc mains are considered different types of power supply.

To determine the influence of variations in the supply voltages on the characteristics, supplementary measurements may be carried out at overvoltages and undervoltages, these being chosen appropriately with due regard for the manufacturer's specifications.

14.1 Mains-Operated Receivers

14.1.1 The rated voltage at the rated frequency shall be applied to the receiver. For receivers with more than one rated operating voltage or frequency, a specified rated voltage, at a rated frequency, shall be applied.

14.1.2 *Overvoltages and Undervoltages*

The rated voltage + 10 percent and the rated voltage — 10 percent at a rated frequency shall be applied.

For receivers with more than one rated operating voltage or frequency : the highest rated voltage + 10 percent at the lowest rated frequency and the lowest rated voltage — 10 percent at the highest rated frequency shall be applied, where tappings for a range of voltages are provided, the appropriate range shall be selected for the measurements.

14.2 Accumulator-Operated Receivers

14.2.1 *Normal Conditions*

The normal operating voltage for accumulator batteries shall be 2 0 V per cell for lead batteries not under charge, 2·2 V per cell for lead batteries under charge and 2·4 V per cell for car batteries, measured at the terminals of the battery. If accumulator other than lead accumulators are used, these voltages per cell shall be chosen accordingly and stated with the results (*see also* Table 2)

14.2.2 *Overvoltage and Undervoltage*

The undervoltage for lead accumulators shall be 1·8 V per cell. The overvoltage for lead accumulators of motor-cars shall be at 2·6 V per cell. If accumulators other than lead accumulators are used, the undervoltage and overvoltage per cell shall be chosen accordingly and stated with the results (*see also* Table 2).

NOTE — For batteries in vehicles, switching peaks of very short duration and greatly exceeding the normal operating voltage may occur, whilst at low operating temperatures higher continuous voltage may be encountered.

14.3 Primary Battery-Operated Receivers

14.3.1 *Normal Conditions*

The normal operating voltages for primary batteries are given in IS 2576 : 1975. The normal operating voltage for primary batteries of the Leclanché type is fixed at 1·5 V per cell; if other voltages apply, these shall be stated with the result.

14.3.2 *Receivers with Tubes—Undervoltages*

The undervoltage on load for primary batteries of the Leclanché type shall be 1·10 V per cell for batteries supplying filament voltage and 1·00 V per cell for batteries supplying anode voltage.

Normally, the undervoltage shall be obtained by using an adjustable resistor in series with fresh batteries or other source of rated voltage, having negligible internal resistance. The series resistor shall be adjusted only once to obtain the specified undervoltage under conditions of maximum current demand by the receiver.

Alternatively, the undervoltage may by obtained in a similar way using an initial voltage of a specified percentage, for example, 20 percent below the rated voltage value, with an appropriately smaller value for the series resistance; the use of this method shall be explicitly stated with the results.

14.3.3 *Receivers with Semiconductor Devices—Undervoltages*

The undervoltage on load for primary batteries of the Leclanché type shall generally be 0·90 V per cell. If required, additional tests at an undervoltage of 0·75 V per cell may be applied. The undervoltage shall be obtained as indicated in **14.3.2**.

14.4 Additional Information

Table 2 gives a survey of the different overvoltages and under-voltages for various types of operation.

If during operation at the extreme voltages specified, the receiver is unstable, or if the local oscillator fails, measurements shall be made at less extreme voltages. A clear statement of these conditions shall be added to the results.

14.5 Power and Current Consumption of Receivers

The power and current consumption of receivers may be measured under standard measuring conditions for each of the following conditions:

a) Without a radio-frequency input signal (if the receiver is equipped with a muting circuit, this shall be in operation);

b) With a radio-frequency input signal, modulated 30 percent at the standard reference

Table 2 Survey of Voltages for Various Types of Power Supply

(*Clause* 14.4)

1	2	3	4	5
Type of Power Supply for Radio Receivers	**Rated Voltage** *V*	**Normal** *V*	**Operating Voltage Maximum** *V*	**Minimum** *V*
Mains	*U*	*U*	*U* + 10%	*U* − 10%
Primary battery*	1·5	1·5		
For receivers with tubes or valves				
— for filament supply			1·5	1·10
— for anode supply			1·5	1·00
For transistor receivers (delivering			1·5	0·90
distortion-limited output power at the applied voltage)				0·75
Accumulator†				
Lead acid accumulators	2·0	2·0		1·8
— under charge		2·2		
— for car receivers		2·4	2·6	
Nickel-cadmium accumulators with incorporated gas vent	1·2	1·2		1·1
— under charge		1·4		
— for car receivers			1·6	
Nickel-cadmium accumulators of the sealed type	1·2	1·2		1·1
— under charge		1·35		
— for car receivers			1·4	

*Voltage per cell.

†Only if required.

frequency, the receiver delivering one-eight of the rated distortion limited output power.

The measurement may be repeated at over-voltages and under-voltages.

The type of power supply and the operating conditions during the measurement shall be stated.

15 TOLERATION OF SURGE DISCHARGES OF LIMITED ENERGY, APPLIES TO THE ANTENNA INPUT CIRCUIT

15.1 Introduction

Receivers connected to an open antenna are liable to be damaged by surge discharges of limited energy to or from this antenna. Such surge discharges mainly occur during thunderstorms or, in the case of a car radio receiver, by discharging the body of the car, while the antenna is accidentally connected to earth by any means.

Direct lightening dischargers are not dealt with in this section.

The ability of the input circuit of a receiver to endure surge discharges is measured by the highest surge voltage, expressed in kilovolts, or by the highest surge energy, expressed in microjoules after which the receiver does not fail to function.

The energy that the receiver can withstand is dependent on the applied voltage. Therefore, a capacitor with a fixed value (1·5 nF) is chosen as a means of applying the surge. The value of the maximum permissible surge energy, together with the applied voltage, shall be stated by the manufacturer. The applied voltage and the surge energy have a fixed interrelation according to the following formula:

$$E = \frac{1}{2} CU^2$$

where

E = surge energy in joules,

C = capacitance in farads, and

U = applied voltage in volts.

15.2 Method of Test

The receiver shall be in operation, receiving any suitable signal by means of a small antenna having a capacitance of less than 10 pF, a connection to earth being applied if the receiver has an earth terminal.

A surge discharge device is also connected to the aerial and earth terminals of the receiver under test. The surge discharge device consists of a capacitor of 1·5 nF, earthed at one side which, in turn, is charged by adjustable voltage source (for example, 0 kV to 10 kV), and discharged through the input circuit of the receiver, by means of a switch

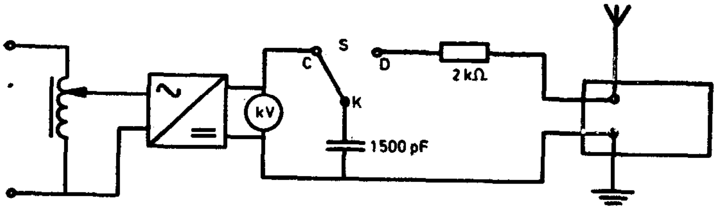


FIG. 3 EXAMPLE OF THE ARRANGEMENT FOR MEASURING THE TOLERATION OF SURGE DISCHARGES APPLIED TO THE ANTENNA INPUT CIRCUIT

or relay connected to the aerial terminal through a current-limiting resistor of 2 000 Ω. If the receiver does not have an earth terminal, it shall, in the case of a mains receiver, be operated from a supply which has one pole earthed. A battery receiver shall be placed on a metal sheet which shall be considered as earth. The receiver shall be insulated from the metal sheet by a thin (about 0·5 mm thick) dielectric material.

Figure 3 gives an example of the arrangement for measuring the toleration of surge discharges.

NOTE — The switch or relay shall have stray capacitances of 15 pF or less, between contacts *C* and *D* and from contact *D* to earth. Care is required in the design to avoid spurious effects due to contact bounce.

With the switch in the 'charge' position *C*, the voltage source is adjusted for the specified voltage or for the voltage corresponding to the specified surge energy whichever is applicable.

The switch (or the relay) shall then be manipulated at least ten times from the 'charge' position *C* to the 'discharge' position *D* and back.

If the receiver, after this series of discharges, is still in normal operating condition, it is deemed to pass the test for the applied dc polarity.

The test shall be repeated after reversing the polarity of the adjustable voltage source.

NOTE — The aerial used for normal operation shall not be connected to the receiver because its capacitance to earth would absorb part of the discharge energy. The small aerial used for the test shall not be touched during the test and shall be discharged to earth when the measurements are completed, to avoid risk of shock.

SECTION 2 AUDIO FREQUENCY MEASUREMENTS

16 INTRODUCTION

Since the technology and applications of sound radio receivers are closely allied to those of sound system equipment, it is desirable that the same methods of measurement and the same terminology should be used for both types of equipment. A series of Indian Standards (IS 9302 series) has been brought out on methods of measurements for sound system equipment. Reference is therefore made to this standard for the audio-frequency characteristics and their methods of measurement to be used for sound radio receivers.

16.1 Reference Audio Frequency Output Level

For consistency with IS 9302 series, the reference audio-frequency output level shall be 10 dB below the rated (distortion limited) output voltage or power. Alternatively, a stated, preferred value of output voltage or power, not directly related to the rated value, may be used; the preferred voltage is then 500 mV and the preferred values of output power are 500 mW, 50 mW and 1 mW.

16.2 Audio-Frequency Substitute Load

The audio-frequency substitute load is a physical impedance (usually resistive) whose impedance is equal to the rated load impedance for the output terminals under consideration and which can tolerate the maximum output voltage and current available at those terminals for a sufficiently long period of time to carry out measurements without significantly changing its electrical characteristics.

16.3 Overall Characteristics

Overall characteristics are characteristics measured at audio-frequency output terminals with an RF input signal. The terms 'overall' is used to distinguish these characteristics from the same or similar characteristics measured with an AF input signal applied to an AF input.

16.4 Method of Measurement of Output Power

The loudspeaker of the receiver or the standard artificial load shall be connected to the output circuit of the receiver during the measurement of the output power. When the loudspeaker is used as the load, the modulus and phase angle of the speach coil impedance shall be taken into account in the calculation of the output power. The indication on the instrument for measuring the output power shall be based on the measurement of RMS values of voltage and/or current. It is permissible to introduce filters into the output meter circuit for the reduction of hum, noise or other interference provided that their attenuation is taken into account in the calibration and the impedance presented to the receiver is maintained. The results are expressed in dB (mW) or in mW or W.

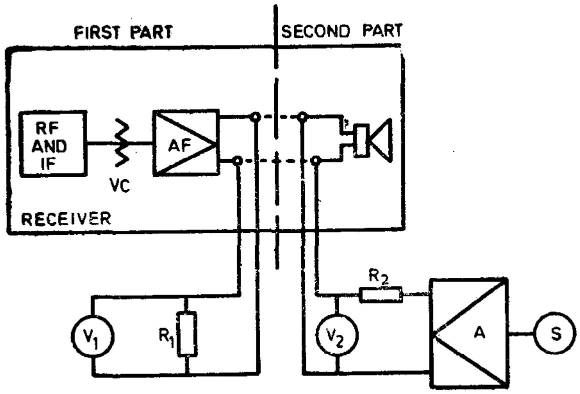
17 ACOUSTIC FEEDBACK

17.1 Introduction

The acoustic energy from a loudspeaker included in a sound radio receiver may cause other components in the receiver to vibrate, and some of these components tend to respond to vibration by changing their electrical characteristic (varying capacitance or the actual generation of a voltage, for example). In this way a signal may be introduced into the audio-frequency part of the receiver, and this phenomenon is called acoustic feedback. It can be characterised by the loop gain of the system, and this usually varies considerably with frequency.

17.2 Method of Measurement

At a suitable point in the audio-frequency part of the receiver, such as the loudspeaker terminals, the circuit shall be separated into two parts, the first part being connected to an impedance is nearly equal as necessary to the input impedance of the second part over the whole audio-frequency range. A source of audio-frequency signals shall be connected to the input of the second part through an impedance as nearly equal as necessary to the output impedance of the first part over the whole audio-frequency range. The volume control shall be set at maximum. A diagram of the arrangement is given in Fig 4.



A	High quality a. f. amplifier
S	A. F. signal source
R_1	A. F. substitute load
R_2	Impedance equal to the output source impedance of the a. f. part of the receiver
V_1	Voltmeter measuring the output voltage of the first part of the receiver
V_2	Voltmeter measuring the input voltage to the second part of the receiver
VC	Volume control, set at maximum

FIG. 4 BLOCK DIAGRAM OF THE ARRANGEMENT FOR MEASURING ACOUSTIC FEEDBACK

The frequency of the source shall be varied over the audio-frequency range, and the source emf adjusted, if necessary, at each frequency to simulate the spectral distribution of the signals supplied by the first part of the receiver in normal operation. The output voltage of the first part, and the voltage cross the input of the second part, shall be measured at each frequency for several values of source emf, care being taken that non-linearity does not occur. The phase of the output voltage relative to that of the voltage across the input of the second part may also be measured. Measurements may also be made at various settings of the volume and tone controls.

17.3 Presentation of Results

The results may be expressed graphically with the loop gain *A* expressed in decibels on a linear scale as ordinate, against frequency on a logarithmic scale as abscissa. Families of curves may be plotted for different measuring conditions, which shall be stated in the results. The loop gain *A*, expressed in decibels, is given by

$$20 \log_{10} \frac{\text{Output voltage of the first part}}{\text{Input voltage to the second part}}$$

Similarly the relative phase in degrees on a linear scale may be plotted against frequency on a linear scale. Self-oscillation may occur if the inphase component of the complex loop-gain is greater than unity, but distortion and frequency response are affected at much lower values of loop-gain.

SECTION 3 RADIO-FREQUENCY SIGNALS

18 STANDARD RADIO-FREQUENCY INPUT SIGNAL

18.1 General

To facilitate the comparison of results, it is desirable to use the same signal conditions for as many measurements as possible, and to change the parameters of the signal, where necessary for measurment purposes, according to a fixed pattern. Table 3 shows the characteristics of the standard signal, first additional values for each parameters, and a set of further values which may be required for some measurements.

18.2 Recommended RF Input Signal Levels

18.2.1 For receivers with open wire aerial:

a) 50 microvolts	— 86 dB (V)
b) 5 millivolts	— 46 dB (V)
c) 0·1 Volt	— 20 dB (V)
d) 1 Volt	0 dB (V)

Table 3 Characteristics of Standard and Additional RF Input Signals

(*Clause* 18.1)

Parameter	Standard Signal	First Additional Value(s)	Other Valves
Frequency	Nearest channel frequency to the centre of the tuning range	Nearest channel frequency to the limits of the tuning range	Channel centre frequencies or others as required
Available power (*see* not)	70 dB (fW) (that is 3·3 nW) or the geometric centre of the dynamic range* of the receivers if significantly different from 70 dB (fW) (*see* Note 1)	As required, preferably in steps of 10 dB relative to 70 dB (fW)	As required
Equivalent free-space electric field strength (for receivers with magnetic antennas)	74 dB (µV/m) or the geometric centre of the dynamic range* of the receiver if significantly different from 74 dB (µV/m)	As required, preferably in steps of 10 dB relative to 74 dB (µV/m)	As required
Modulation factor	Am 30% FM 30%	AM 80% FM 100% (*see* Note 2)	As required *See* Clause 4.1
Modulation frequency	1 kHz	400 Hz	as required

*The dynamic range (of the RF input signal level) is the difference in level between the distortion-limited input signal level and either the gain-limited or the noise-limited sensitivity, whichever is the greater level.

NOTES

1 The equivalent source emf may be calculated using the formula

$$U_0^2 = 4\,PR$$

where P is the available power and R is the rated impedance of the input circuit. For the definition of R for receivers intended for use with open-wire antennas, *see* **20.**

2 The broadcasting system standard should be consulted to determine the deviation corresponding to 100 percent utilization when one or more sub-carriers are transmitted with the main signal. If these sub-carriers are present in the input signal during measurements, the modulation factor should not exceed 100 percent utilization.

18.2.2 For receivers with loop or ferrite rod aerial:

a) 50 microvolt per metre —86 dB (V/m)
b) 5 millivolts per metre —46 dB (V/m)
c) 50 millivolts per metre —26 dB (V/m)
d) 200 millivolts per metre —14 dB (V/m)

19 PRE-EMPHASIS

Where a receiver has been designed for transmissions using pre-emphasis, it is useful, for some measurements, to apply modulation signals including the appropriate pre-emphasis. It should be clearly understood, however, that the use of pre-emphasis is possible only because the programme signals have spectral distributions which are not constant with frequency; consequently the use of pre-emphasis with test signals whose amplitude is independent of, or depends on, frequency according to a different law from that of the programme signals, will cause over-modulation unless the general level of modulation is sufficiently reduced.

20 ANTENNA SIMULATION NETWORKS (ARTIFICIAL AERIALS)

20.1 Whereas the rated source impedances of signal sources for measurement purposes (signal generators, etc) are usually resistive and well-defined, the source impedances of antennas have a wide range of values and are neither resistive nor independent of frequency. It is often necessary, therefore, to insert between the signal source and the receiver input, an antenna simulation network which matches the signal source correctly and presents to the receiver a source impedance simulating that of the appropriate antenna.

For expressing the values of the available power and equivalent source emf of the input signal, the antenna simulation network shall be regarded as part of the receiver. The input impedance (R) of the receiver is then considered to be equal to the rated source impedance of the signal source.

20.2 Antenna Simulation Networks for Open-Wire Antennas in the Frequency Range 100 KHz to 30 MHz

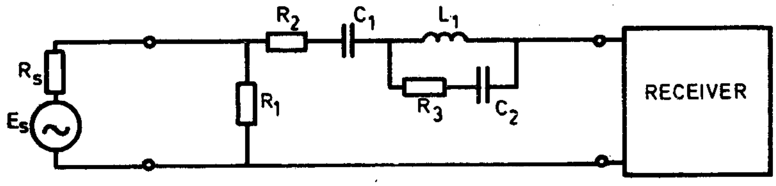
The networks shown in Fig. 5 are examples of networks which have been found satisfactory. Where a receiver is designed for use with an antenna having significantly different impedance characteristics from any of those antennas given below, it will be necessary to devise a special network, details of which shall be given with the results of measurements (*see* **20.3**).

Componet values of the Figures 5E and 5F

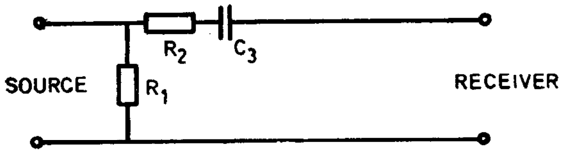
Frequency range (MHz)	Longest dimension of receiver cabinet (cm)	R_2 (Ω)	R_3 (Ω)	L (μH)	C (pF)	Circut Fig.
65·8 to 73	22 to 27	59	16	0·34	5·8	5E
65·8 to 73	27 to 33	50	25	0·5	6·0	5E
65·8 to 73	Above 33	28	47	0·78	5·4	5E
87·5 to 108	22 to 33	25	51	0·25	8·2	5E
65·8 to 108	Car radios	75	38	—	—	5F

These values are based on $R = 75$. For other values of R_1 the value of the parallel combination of resistors $R_3 + R_1$ in the circuit of Fig. 5E, should remain the same as calculated from the table, the condition $R_2 + R_3 = R_1$ being also satisfied. In the circuit of Fig. 5E, the value of R_2 should equal that of R_1. The values given are for an antenna length of 1·2 m and a housing capacitance of 18 pF. The length and capacitance of the antenna cable between the network and the receiver shall be stated with the results.

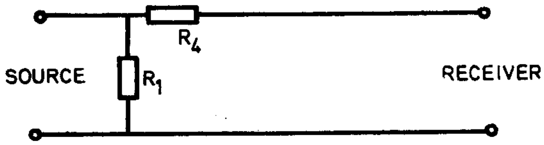
In determining the avilable power from the source the capacitor and inductor are deemed to be part of the receiver, so that the available power is measured or calculated at the point A in Fig. 5E.



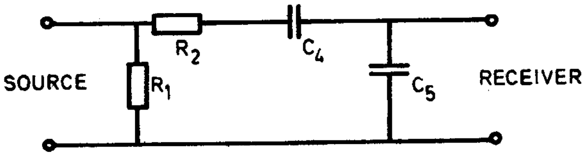
5A Antenna Simulation Networks



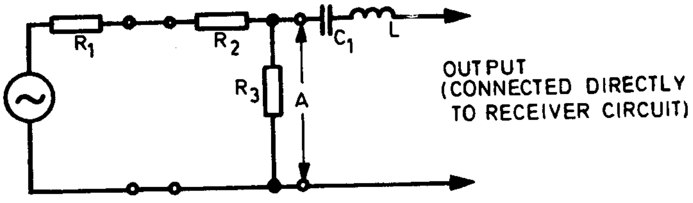
5B Antenna Simulation Networks



5C Antenna Simulation Networks

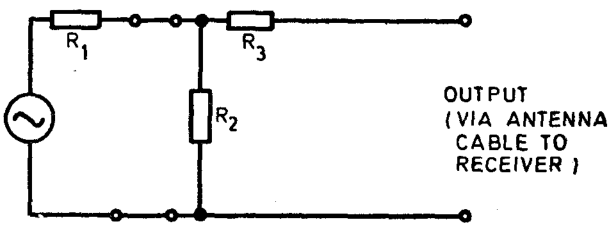


5D Antenna Simulation Networks



5E For Rod and Telescopic Antennas (Approximately ¼ Wavelength)

FIG. 5 ANTENNA SIMULATION NETWORKS — *Contd*



5F For Car Radio Antennas

FIG. 5 ANTENNA SIMULATION NETWORKS

20.3 Other Antenna Simulation Networks

Networks for other frequency ranges, and those simulating other types of antenna, are specially designed for each application.

The design criteria include the following major items:

a) The network shall present to the receiver an impedance as nearly equal as necessary to that of the real antenna over the required frequency range;

b) The network impedance shall match the source impedance of the signal source to a sufficient degree of accuracy; and

c) The attenuation of the network shall not vary very rapidly with frequency, and shall be as is reasonably practicable (except where attenuation is deliberately included).

21 COMBINING NETWORKS

For some measurements it is necessary to apply two or more signals to the input of the receiver, and a combining network is usually necessary in order to preserve accuracy and avoid interaction (intermodulation, for example) between the signal sources.

Typical networks for combining two and any number of sources are shown in Fig. 6.

Where sources of different impedances are to be combined, it is usually more convenient to use matching pads to make all the sources have effectively the same impedance and then to use one of the networks shown.

It is usually more accurate to use the output level controls (attenuators) of the sources to set the relative levels of the signals rather than to incorporate deliberate attenuation in the combining network.

22 BALANCED RADIO-FREQUENCY INPUT CIRCUITS

22.1 General

A balanced input may be provided for either or both of the following reasons:

a) Because the receiver is intended for use with a balanced antenna (for example, a horizontal dipole), and

b) To reduce the effect of interference entering via the antenna of feeder cable, as an unbalanced signal.

The efficiency of the balanced input is measured by the unbalance ratio, or common-mode rejection ratio (CMRR).

22.2 Method of Measurement of Unbalance Ratio

22.2.1 The receiver is brought under normal working conditions.

NOTE — The most accurate and reliable method of obtaining a balanced signal from an unbalanced source is to use transformer.

22.2.2 A suitable output characteristic of the receiver is chosen and its value measured. The audio-frequency output level may or may not be a suitable characteristic; this depends on the design of the receiver. Alternatives may be an automatic gain control (a. g. c.) voltage or a carrier-strength meter reading.

22.2.3 The signal source is then removed and an unbalanced source connected in accordance with Fig. 7. The standard RF input signal is applied and the signal level then adjusted to obtain the same value of the output characteristic as in **22.2.2**.

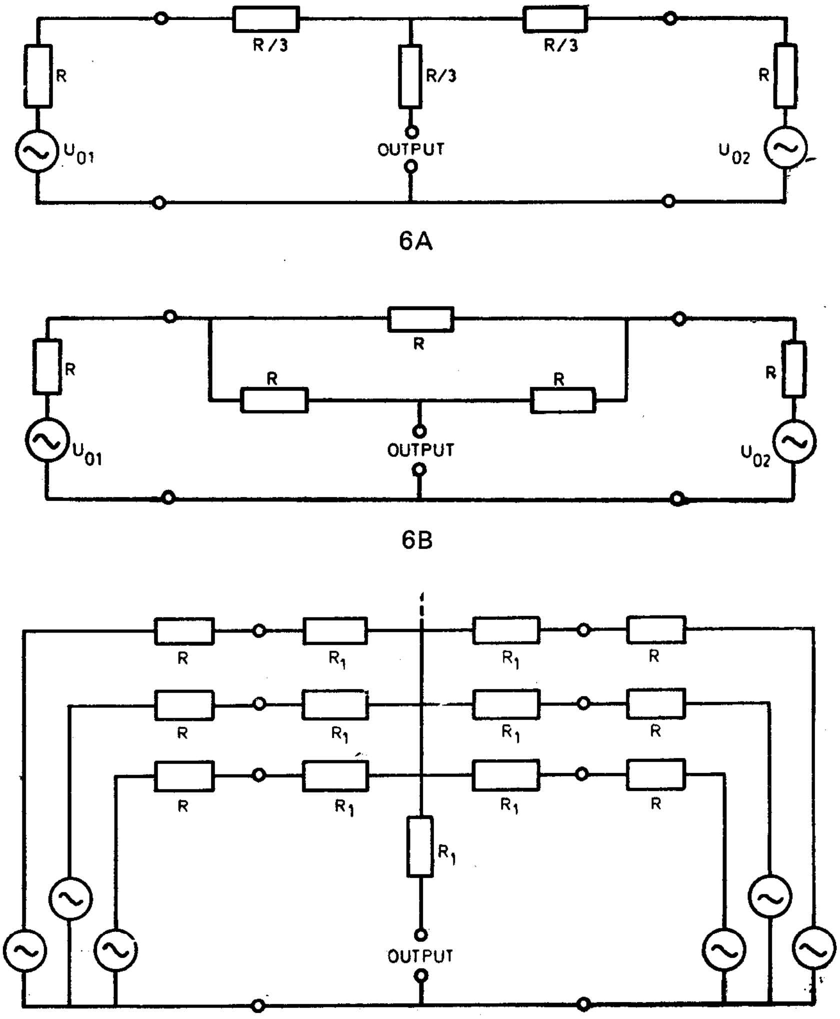
22.2.4 The measurement may be repeated beginning with other levels of signal input in **22.2.1**.

22.2.5 The results are tabulated, or plotted, as the ratio, expressed in decibels, of the source emf of the unbalanced signal to that of the balanced signal, against the source emf of the balanced signal.

23 INPUT ARRANGEMENTS FOR RECEIVERS WITH MAGNETIC ANTENNAS

23.1 Measurement Apparatus

The input arrangement consists of a screened

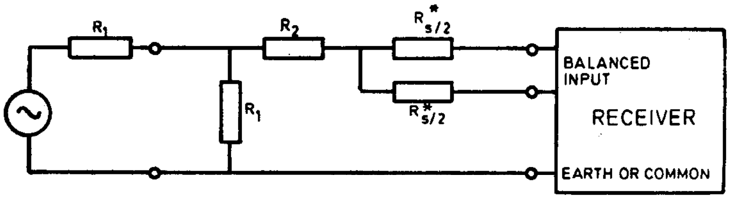


6A

6B

6C

FIG. 6 COMBINING NETWORKS



$R_2 = R_u - R_1$, where R_u is the source impedance of the unbalanced source. Its value is assumed to be 600 Ω, unless another value is known to apply.

R_1 is the source impedance.

*Matched at the operating frequency more closely than the reciprocal of the unbalance ratio.

FIG. 7 APPLYING AN UNBALANCED SIGNAL TO A BALANCED INPUT

loop which is connected through a series resistance and a specified cable to a radio-frequency signal source with a known source emf.

The loop consists of three turns of 0·8 mm diameter solid copper wire suitably insulated. These turns are placed in a copper tube of 10 mm to 12 mm diameter, which is bent into a circle of 0·25 m as mean diameter. The copper tube is prevented from acting as a short-circuiting turn by having a break at the top of the circle. This loop will have an inductance of about 7·5 μH.

A small housing at the base of the loop contains a resistor, which is connected in series between the unearthed end of the winding and the inner conductor of a shielded coaxial cable leading to the signal generator, where it shall be connected by means of a completely shielded coaxial plug. This coaxial cable shall be 1·2 m long, and have a total capacitance of 120 pF.

The magnetic aerial to which the field shall be applied is placed in position P_1 with respect to the loop of the input arrangement if the former is an air-cored loop aerial, and in position P_2 if it is a ferrite-cored loop aerial (*see* Fig. 8).

The equivalent mean electric field strength in position P_1 is expressed as:

$$E_1 = \frac{60 A U_0 N}{d_1^3 (Ri + R)} \ \mu\text{V/m}$$

whilst in position P_2 it will be:

$$E_2 = \frac{30 A U_0 N}{d_2^3 (Ri + R)} \ \mu\text{V/m}$$

where

A = area of the loop in square metres calculated from its mean diameter,

U_0 = apparent source emf of the signal generator expressed in microvolts,

N = number of turns of the loop,

d_1 or d_2 = distance of the chosen position to the centre of the loop in metres,

R_i = source impedance of the signal generator expressed in ohms, and

R = resistance in the base of the loop expressed in ohms.

For a chosen distance $d_1 = d_2 = 0·6$ m and a value of R such that $Ri + R = 409$, both formulae can be simplified to:

$E_1 = 0·1\ U_0\ \mu$V/m for position P_1, and

$E_2 = 0·05\ U_0\ \mu$V/m for position P_2.

U_0 being expressed in microvolts.

NOTE — The field strength is calculated for the position P_1 or P_2 and does not accurately represent the average field strength, unless the receiving loop or ferrite aerial is small compared with 0·6 m.

This method can be used inside and outside screened rooms, but in the first case a measurement shall be made of the actual field strength obtained, as field distortion due to the presence of the shielding may be expected as a result of reflection effects.

This may be restricted to the frequencies or ranges of frequencies involved in the measurements to be carried out.

For the method of measurement, *see* Annex D.

23.2 Considerations and Limitations

This method requires the distance d_1 or d_2 to be adhered to exactly, as it appears in the third power in the relevant formulae. As the chosen value for the distance d_1 or d_2 of 0·6 m is not small in comparison with the dimensions of the screened rooms generally used, field distortion is highly probable, and therefore measurement of the actual magnetic field strength is unavoidable. A commercial instrument, of which the loop of the input arrangement has the construction and dimensions as indicated in Fig. 8, was investigated. It was found that the loop only, without cable

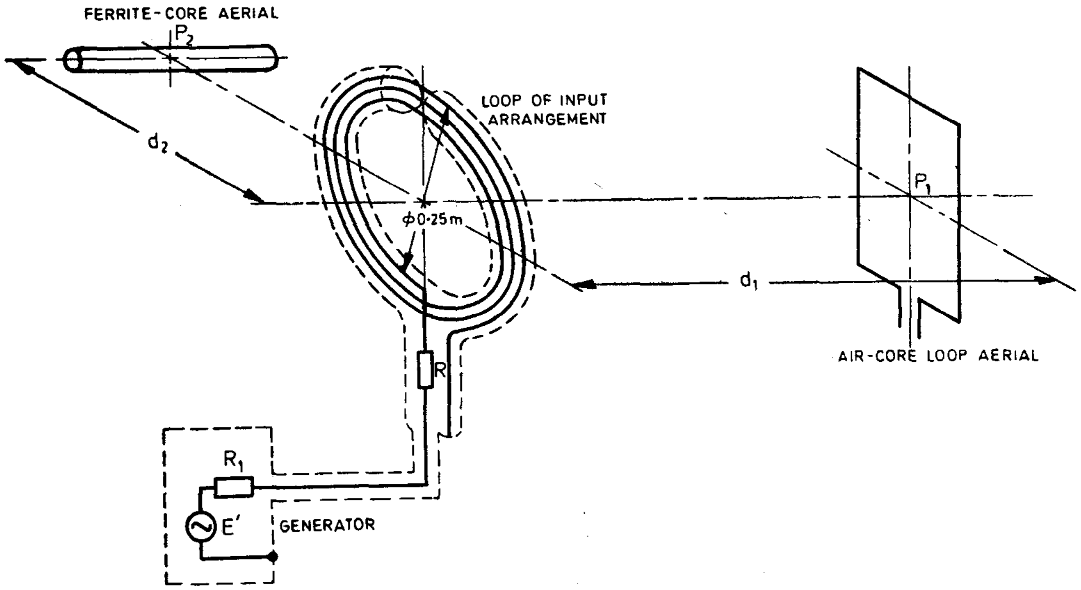


FIG. 8 SMALL SCREENED LOOP (φ = 0·25 m)

and resistor in the base, has an anti-resonance of about 8·9 MHz, which limits the frequency range of the apparatus to a frequency well below this value.

NOTE — Measurements have shown that this apparatus is usable up to a frequency of 2·5 MHz.

SECTION 4 OPERATING FREQUENCY AND ITS STABILITY

24 STABILITY OF THE OPERATING FREQUENCY

24.1 Introduction

The operating frequency is the carrier frequency of the signal to which the receiver would be correctly tuned. Several different criteria have been applied to decide when a receiver is correctly tuned to a signal of fixed carrier (centre) frequency, only some of which are related to the way in which a receiver is tuned when in normal use. Once tuned correctly to a signal the operating frequency of the receiver may vary depending on changes in ambient temperature, self-heating in the receiver or changes in input signal level.

24.2 Method of Measurement of the Variation of Operating Frequency with Time

24.2.1 *Method*

a) The receiver is brought under standard measuring conditions and then switched off for a time long enough for all parts of the receiver to be at ambient temperature.

NOTE — The ambient temperature shall be kept as nearly constant as is practicable.

b) The receiver is then switched on and the operating frequency determined at regular time intervals by retuning the signal source, using the appropriate criterion for current tuning, leaving the receiver tuning control(s) in a fixed position. The carrier frequency of the signal source is noted at each time.

c) The measurements shall be continued until the operating frequency becomes practically constant, which may take several hours.

24.2.2 *Presentation of Results*

The results may be tabulated or expressed graphically with time as abscissa and operating frequency, or the difference between the operating frequency and that under standard measuring conditions, as ordinate.

24.3 Method of Measurement of the Variation of Operating Frequency with Supply Voltage

24.3.1 *Method*

a) The receiver is brought under standard measuring conditions.

b) The supply voltage is then varied in steps between the maximum and minimum permitted values and the operating frequency determined at each step.

24.3.2 *Presentation of Results*

The results may be tabulated or presented graphically.

24.4 Method of Measurement of the Variation of Operating Frequency with RF Input Signal Level

24.4.1 *Method*

a) The receiver is brought under standard measuring conditions.

b) The RF input signal level is then varied in steps and the operating frequency determined at each step. particular attention being paid to the effect with strong signals and, if automatic frequency control is in operation, with weak signals (*see* **25**).

24.4.2 *Presentation of Results*

The results may be tabulated or presented graphically.

24.5 Method of Measurement of the Variation of Operating Frequency with Ambient Temperature

24.5.1 *Method*

a) The receiver is brought under standard measuring conditions in an enclosure within which the ambient temperature can be varied.

NOTE — The volume of the enclosure shall be at least 30 times the volume of the receiver, and means shall be provided to stir the air in the enclosure.

b) The ambient temperature is then varied in steps over the permitted range, and the receiver temperature allowed to stabilize at each step. This may require an hour or more. The operating frequency is then determined.

24.5.2 *Presentation of Results*

The results may be tabulated or presented graphically.

25 AUTOMATIC FREQUENCY CONTROL

Automatic frequency control (afc) is a feedback technique in which a variation of operating frequency is detected and an error signal generated which may be used to reduce the original variation.

Since the details of the method of measurement of the afc characteristics vary with the type of receiver, this is given in subsequent parts of this standard.

The measurements given in **24** may be repeated with afc in operation in order to determine its ability to reduce variations in operating frequency.

SECTION 5 PROPERTIES OF TUNING SYSTEMS

26 GENERAL MECHANICAL PROPERTIES OF TUNING SYSTEMS

26.1 Tuning Drive Factor

The tuning drive factor of a receiver is the travel, for a certain change, in frequency of a point on the periphery of the normally handled part of the tuning control. It is expressed in millimetres per kilohertz.

This measurement shall be made at preferred measuring frequencies. Care shall be taken that the results of the measurements are not influenced by play in the tuning mechanism (*see* **26.4**).

26.2 Tuning Scale Factor

The tuning scale factor of the scale of a receiver is the scale length corresponding to a certain change in frequency. It is expressed in millimetres per kilohertz.

This measurement shall be made at preferred measuring frequencies.

26.3 Calibration Error

The difference between the operating frequency of a receiver and the value read on its dial is the calibration error of the receiver at that operating frequency. It is expressed in kilohertz and its maximum value for each tuning range shall be stated, together with the chosen method of tuning. The receiver is tuned to a signal of known frequency, its accuracy being stated with the results.

The calibration error shall preferably be determined at preferred measuring frequencies and, unless otherwise specified, with the standard measuring signal.

Care shall be taken that the results of the measurement are not influenced by play in the tuning mechanism (*see* **26.4**).

If necessary, the calibration error shall be determined by tuning the receiver in both directions of the frequency scale.

The receiver shall have reached its steady temperature state before measurements are started.

26.4 Play in the Tuning Mechanism

Play in the tuning mechanism is seperated into the play of the tuning knob and the play of the indicator. Measurement of play shall be made by tuning the receiver twice to the same frequency turning the tuning knob first in one direction and then in the opposite direction. In the case of a super-heterodyne receiver, the two adjustments to the same operating frequency shall be ascertained by the zerobeat method, using an auxiliary generator tuned to the intermediate frequency of the receiver. Due to play, two different positions of the tuning knob and likewise two different positions of pointer will be found.

The play of the tuning knob is defined as the ratio of the travel of a point on the periphery of the tuning knob between the positions found by tuning in opposite directions to the same frequency, to the total travel of that point required to complete the full stroke of the scale. The travel between the two positions of the knob may be translated into kHz at any operating frequency of the receiver and the results compared with the tuning drive factor in accordance with **26.1**.

The play of the indicator is defined as the ratio of the difference between the two positions of the indicator found by tuning in opposite directions to the total movement of the pointer. Also in this case, the difference between the two positions may be translated into kHz and the results compared with the tuning scale factor in accordance with **26.2**.

27 PERFORMANCE CHARACTERISTICS OF PUSH-BUTTON TUNING SYSTEMS

27.1 Introduction

Push-button tuning systems may be divided into two groups:

a) Mechanical systems, in which one of a number of preselected frequencies is chosen, either in a purely mechanical way, or by means of a suitable mechanism, for example, an electric motor;

b) Electrical systems, in which one of a number of preselected frequencies is chosen by mean of push-botton switches, either directly, or by actuating a switching system which connects the relevant group of pretuned circuits or crystals, or adjusts synthesiser circuits or voltage-dependent capacitors.

Both systems may be or may not be equipped with a system of automatic frequency control.

It is necessary to determine the tuning errors that may occur and their dependence on various conditions.

27.2 Method of Measurement

Receivers with a push-button tuning system which are not provided with automatic frequency control shall initially be tuned according to the manufacturer's instructions to an appropriate preferred frequency, after the push-button chosen for the measurement has been pressed.

If the receiver is provided with a system of automatic frequency control which can be switched off, the tuning and all subsequent measurements shall be performed with the automatic frequency control out of operation.

If the incorporated automatic frequency control cannot be switched off, the receiver shall be tuned as prescribed in the first paragraph, but all subsequent frequency measurements shall be carried out in the absence of any signal or disturbance which may influence the frequency of the oscillator to be measured.

In both cases the functioning of the automatic frequency control shall be checked separately.

During the following frequency measurements on radio-frequency input signal shall be applied. The oscillator frequency f_0O corresponding to the resulting operating frequency, shall be measured and used as the reference frequency for this series of measurements.

After the measurement of oscillator frequency with the first button pressed, another button, corresponding to a differerent frequency is pressed. The first button chosen for the measurement is now pressed again and the resulting oscillator frequency measured. This procedure is repeated until a sufficient number of frequency measurements has been obtained, but at least ten times, resulting in, for example, ten possibly different frequencies, f_{01} to f_{010}.

The differences between these frequencies are the tuning errors, which shall be presented in the following way:

a) The individual tuning error for n measurements:

$$\Delta f_i = f_{0i} - f_0\text{O Hz}$$

$$i = 1 \text{ ......} n$$

b) The mean tuning error for n measurements:

$$\overline{\Delta f_{(n)}} = \frac{1}{n}\sum_{i=1}^{i=n} \Delta f_i \text{ Hz}$$

c) The standard deviation from the mean tuning error for n measurements :

$$S_{(n)} = \pm\sqrt{\frac{1}{n-1}\sum_{i=1}^{i=n}\left\{\Delta f_i - \overline{\Delta f_{(n)}}\right\}} \text{ Hz}$$

If the mean tuning error or its standard deviation depend on the magnitude and sense of the difference between the frequency of the starting position and the chosen operating frequency, the dependence of the values of the mean tuning error and its standard deviation can be determined and given in a graphical form.

The measurements shall be repeated with other combinations of push-buttons, from which the most unfavourable performance shall be derived and stated with the results.

The measurement shall also be repeated at other frequencies.

If the accuracy of tuning depends on the force with which a button is pressed or on the voltage applied to the driving mechanism, these values shall be varied between their permissible limits and quoted with the resulting tuning errors at these limits.

27.3 Presentation of the Results

If the mean tuning error or its standard deviation depend on the sense and the frequency spacing between the frequency of the starting position and the chosen operating frequency, these relations shall be presented graphically by plotting, as abscissa, the difference between the frequency of the starting position and the chosen operating frequency, plus or minus being indicated, and the corresponding mean tuning error $\overline{\Delta f(n)}$ and its standard deviation $S_{(n)}$, linear as ordinate frequency being expressed in kHz. The operating frequency corresponding to the frequency f_0O and the number of measurements (n) shall be given with the results.

Figure 9 shows an example of curves giving the mean tuning error and its standard deviation for a push-button tuning system, as functions of the difference between the frequency of the starting position and the chosen operating frequency.

28 PERFORMANCE CHARACTERISTICS OF AUTOMATIC SEARCH SYSTEMS

28.1 Introduction

Automatic search systems for radio receivers are generally operated by pushing a start button, after which an automatic device operates the tuning control, until it is stopped by the first signal encountered with an adequate level (referred to as the stop signal).

The performance characteristics to be measured are:

a) the tuning error as a function of the level of the stop signal;

b) The tuning error as a function of the difference between the operating frequency of the starting position and that of the stop signal;

c) the minimum level of the stop signal, giving a specified permissible tuning error,

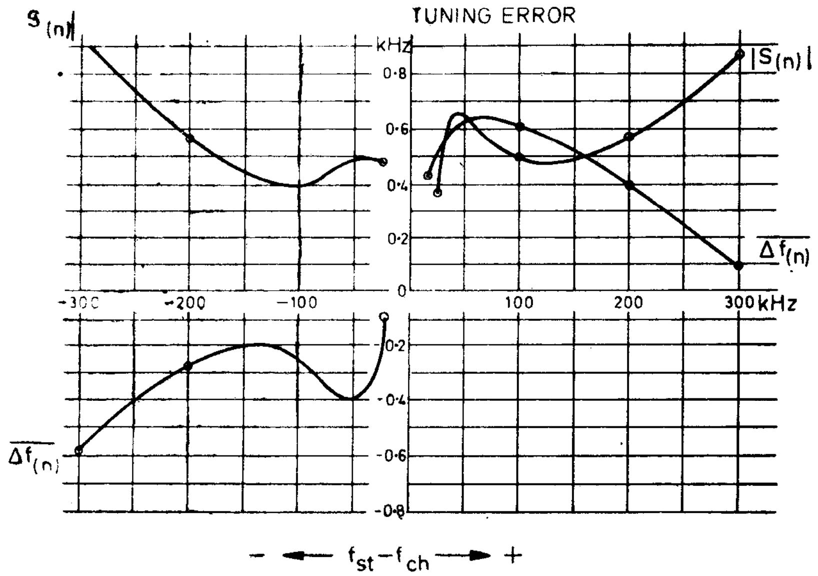


Fig. 9 Mean Tuning Error and Its Standard Deviation of a Push-Button Tuning System, as Functions of the Difference Between the Frequency of the Starting Position, (f_{st}) and the Chosen Operating Frequency, f_{ch} of 1·0 MHz and for $n = 10$ Measurements

as a function of the frequency of the stop signal.

28.2 Methods of Measurement

With regard to the performance characteristics given above, the following three related methods of measurement shall be used.

28.2.1 *The Tuning Error as a Function of the Level of the Stop Signal*

A stop signal modulated 30 percent with the standard reference frequency shall be applied to the receiver with a standard frequency which is near to the middle of the frequency range to be investigated this frequency being stated with the results. The receiver shall be manually tuned to this signal by an appropriate method.

The oscillator frequency f_0O, corresponding to the resulting operating frequency, shall be measured and used as the reference frequency for this series of measurements. By operating the start button, the automatic search system is put into operation, until the originally chosen stop signal is reached again and stops the automatic device.

The pressing of the start button is repeated several times and after each stop at the stop signal the resulting oscillator frequency shall be measured.

This procedure is repeated until a sufficient number of frequency measurements has been obtained, for example, ten times resulting in ten, possibly different, frequencies f_{01} to f_{010}.

The results are evaluated using the formulae of **27.2**, the measurements being repeated for a range of levels of the stop signal in order to find the relation between this level and the resulting error.

28.2.2 *The Tuning Error as a Function of the Difference Between the Operating Frequency of the Starting Position and that of the Stop Signal*

The method of measurement is identical to that described under **28.2.1**, the level of the stop signal, however, being kept constant at the level which has been found to be suitable as a result of the measurements made according to **28.2.1**.

The starting position shall be the same for each series of (for example ten) measurements, and for each of these series shall be determined by a known difference between its operating frequency and that of the stop signal. The values of the differences depend on the frequency range to be investigated, whilst the various starting positions shall preferably be obtained by means of the signal of a second signal generator but may also be obtained manually.

The measurements shall be repeated for several starting positions with other frequency differences both greater and less than that of the stop signal.

In the latter case, the frequency f_{01} shall only be measured if the stop singal is reached directly from the starting position.

The measurements shall also be repeated at other positions of the threshold control, if present.

28.2.3 *The Minimum Level of the Stop Signal Giving a Specified Permissible Tuning Error, as a Function of the Frequency of the Stop Signal*

The method of measurement as described under **28.2.1** is carried out until a specified permissible tuning error is obtained, defined by:

$$\overline{\Delta f_{(n)}} + 2\,S_{(n)} = 2\ \text{kHz}$$

where the value 2 is an example utilizing a second sign as starting position. It shall be repeated for several values of the frequency of the stop signal.

The difference between the frequency of the stop signal and that of the starting position shall be so large that an increase of this difference does not materially change the value of resulting error (*see* **28.2.2**). The frequencies of the stop signal shall be chosen according to **3.2**, the value of the steps depending on the frequency range to be investigated. At least the two values of preferred frequencies which are nearest to both ends of the frequency range under investigation shall be used.

28.3 Presentation of the Results

28.3.1 The dependence of the mean tuning error $\overline{\Delta f_{(n)}}$ and its standard deviation $S_{(n)}$ on the stop signal shall be presented graphically by plotting as abscissa the level of the radio-frequency input signal, on a linear scale, and as ordinate the corresponding mean tuning error $\Delta f_{(n)}$ and its standard deviation $S_{(n)}$ indicating their sign, expressed in kilohertz, on a linear scale.

The frequency of the stop signal, together with the number of measurements (n), shall be given with the results.

An example of curves, showing the mean tuning error and its standard deviation for an automatic search system as function of the level of the radio-frequency input signal is given in Fig. 10.

28.3.2 The dependence of the mean tuning error $\overline{\Delta f_{(n)}}$ and its standard deviation $S_{(n)}$ on the difference between the operating frequency of the start-position and that of the stop signal shall be presented graphically by plotting this difference as abscissa in kHz and the corresponding mean tuning error $f_{(n)}$ and its standard deviation $S_{(n)}$, indicating their sign, also in kHz, as ordinate both scales being linear.

The frequency of the stop signal, together with its level and the number of measurements (n), shall be given with the results.

An example of curves, showing the mean tuning error and its standard deviation for an automatic search system as a function of the frequency difference between the starting position and the stop signal is given in Fig. 11.

28.3.3. The dependence of the level of the stop signal, for a specified permissible tuning error, on the frequency of the stop signal, shall be presented graphically by plotting as abscissa the frequency of the stop signal expressed in kHz or in MHz as the case may be, on a logarithmic scale, and as ordinates the minimum level of the radio-frequency input-signal for the specified permissible tuning error on a linear scale (on the left-hand side of Fig. 12) as well as the frequency difference between that start signal and the stop signal, expressed in kilohertz, also on a linear scale (on the right-hand side of Fig. 12).

The value of specified permissible tuning error

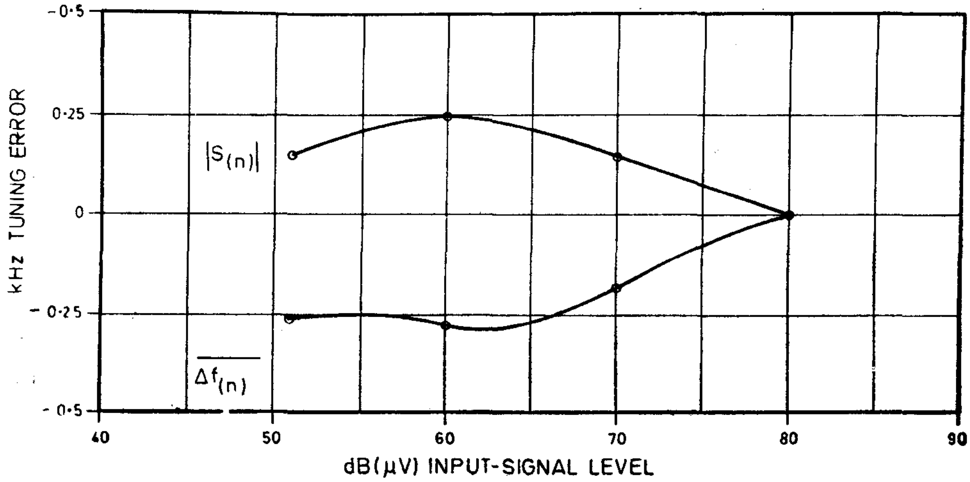


FIG. 10 MEAN TUNING ERROR AND ITS STANDARD DEVIATION FOR AN AUTOMATIC SEARCH SYSTEM AS FUNCTIONS OF THE LEVEL OF THE RADIO-FREQUENCY INPUT-SIGNAL, FOR f_{stop} = 1·4 MHz AND n = 10 MEASUREMENTS

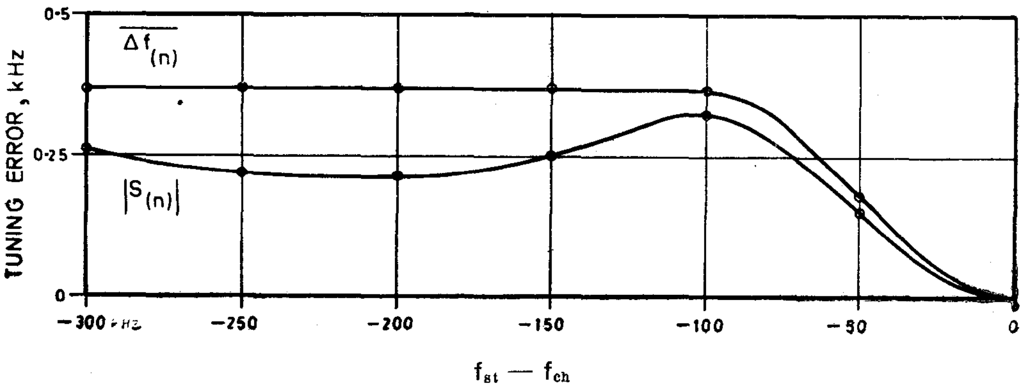


FIG. 11 MEAN TUNING ERROR AND ITS STANDARD DEVIATION FOR AN AUTOMATIC SEARCH SYSTEM, AS FUNCTIONS OF THE FREQUENCY DIFFERENCE BETWEEN THE STARTING POSITION AND THE STOP-SIGNAL FOR f_{stop} = 1·4 MHz AT AN INPUT-SIGNAL LEVEL OF 60 dB (µV) AND n = 10 MEASUREMENTS

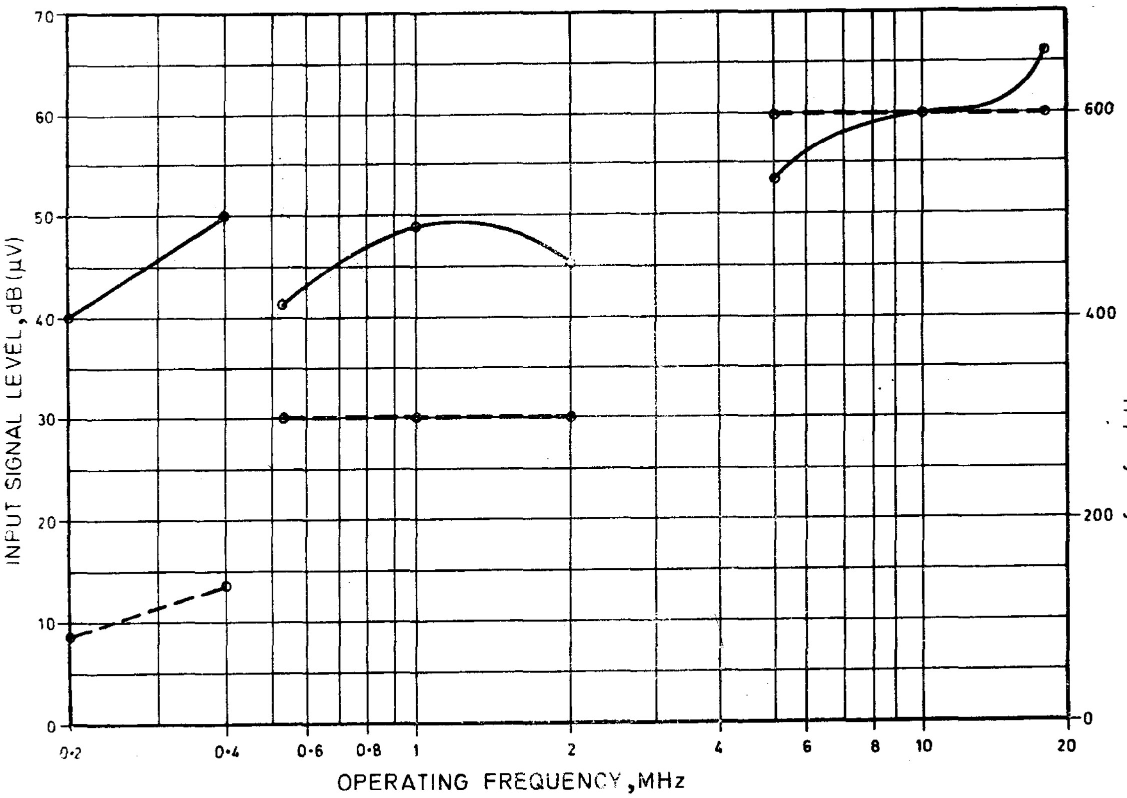


FIG. 12 MINIMUM LEVEL OF THE RADIO-FREQUENCY INPUT-SIGNAL, FOR AN AUTOMATIC SEARCH SYSTEM, FOR A PERMISSIBLE TUNING ERROR CORRESPONDING TO $\Delta f_{(n)} + [S_{(n)}]$ = 2 kHz, AS FUNCTIONS OF THE INPUT SIGNAL FREQUENCY, AND OF THE FREQUENCY DIFFERENCE BETWEEN THE START SIGNAL AND THE STOP SIGNAL (INDICATED WITH DOTTED LINES) FOR n = 10 MEASUREMENTS

$\overline{\Delta f_{(n)}} + 2(S_{(n)})$ in kilohertz, and the number of measurements (n) shall be given with the results.

An example of curves, showing the minimum level of the RF input signal for an automatic search system for a specified permissible tuning error, as a function of its frequency together with the frequency difference between the start signal and the stop signal, is shown in Fig. 12.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
614 : 1964	Methods of measurements on receivers for amplitude modulation broadcast transmissions (*revised*)
616 : 1986 (IEC Pub 65 : 1985)	Safety requirements for mains operated electronic and related apparatus for household and similar general use (*second revision*)
1885 (Part 22) : 1967	Electrotechnical vocabulary: Part 22 Equipments for radio-communications, transmitting and receiving
1885 (Part 24) : 1967	Electrotechnical vocabulary: Part 24 Broadcasting sound and television
2731 : 1964	Methods of measurements on receivers for frequency modulation broadcast transmissions
4546 : 1983	Methods of measurements of radiated and conducted interference from receivers for amplitude modulation frequency modulation and television broadcast-transmission (*first revision*)
6964 : 1973	Octave, half-octave and third-octave band filters for analysis of sound and vibrations
8159 : 1976	Scales and sizes for plotting frequency characteris tics and polar diagrams
9000 (Part 1) : 1988	Basic environ mental testing procedures for electronic and electrical items: Part 1 General (*first revision*)
9302	Characteristic and methods of measurements for sound system equipment
9302 (Part 1) : 1979	General
9302 (Part 2) : 1979	Amplifiers
9302 (Part 3) : 1981	Microphones
9302 (Part 6) : 1986	Headphones and headsets
9302 (Part 7) : 1987	Automatic gain control devices
9302 (Part 9/Sec 1) : 1980	Programme level meters, Section 1 General
9302 (Part 9/Sec 2) : 1980	Programme level meters, Section 2 Peak programme meters, Type I
9302 (Part 9/Sec 3) : 1981	Programme level meters, Section 3 Peak programme meters, Type II
9302 (Part 10) : 1980	Preferred matching values for the interconnection of sound system components
9779 : 1981	Sound level meters

ANNEX B

(*Clause* 7.2.2)

NOISE WEIGHTING NETWORK AND QUASI-PEAK METER

B-1 WEIGHTING NETWORK

B-1.1 The nominal response curve of the weighting network is defined in Fig. 13 which is the theoretical response of the passive network shown in Fig. 14. Table 4 gives the values of this response at various frequencies

The permissible differences between the response curve of measuring networks and this nominal curve are shown in the last column of Table 4 in Fig. 15.

NOTE — The whole instrument is calibrated at 1 kHz (*see* **B-2.6**). In order to make accurate measurement at frequencies giving maximum gain it would be useful to reduce the tolerance at 1 kHz (for instance to ± 0·2 dB).

Table 4 Theoretical Response of the Passive Network

(*Clause* B-1.1)

Frequency (Hz)	Response (dB)	Tolerance (dB)
31·5	—29·9	±2·0
63	—23·9	±1·4*
100	—19·8	±1·0
200	—13·8	±0·85*
400	— 7·8	±0·7*
800	— 1·9	±0·55*
1 000	— 0	±0·5
2 000	+ 5·6	±0·5
3 150	+ 9·0	±0·5*
4 000	+10·5	+0·5*
5 000	+11·7	±0·5
6 300	+12·2	0
7 100	+12·0	±0·2*
8 000	+11·4	±0·4*
9 000	+10·1	+0·6*
10 000	+ 8·1	±0·8*
12 500	0	±1·2*
14 000	— 5·3	±1·4*
16 000	—11·7	±1·6*
20 000	—22·2	±2·0 +2·8*
31 500	—42·7	—x

*These tolerances are obtained by a linear interpolation on logarithmic graph on the basis of values specified for the frequencies used to define the mask, that is, 31·5, 100, 1 000, 5 000, 6 300 and 20 000 Hz.

B-2 CHARACTERISTICS OF THE MEASURING DEVICE

B-2.0 Quasi-peak value method of measurement defined by the time-response characteristic of the measuring set, as described in Table 5 shall be used.

The required dynamic performance of the measuring set may be realised in a variety of ways. It is defined by the performance of the measuring set as described by the following characteristics.

NOTE — After full-wave rectification of the input signal, a possible arrangement would consist of two peak rectifier circuits of different time-constants connected in tandem.

B-2.1 Dynamic Characteristic in Response to Single Tone-Bursts

Single bursts of 5 kHz tone are applied to the input at an amplitude such that the steady signal would give a reading of 80 percent of full scale. The burst shall start at the zero-crossing of the 5 kHz tone and shall consist of an integral number of full periods. The limits of reading corresponding to each duration of tone burst are given in Table 5.

The tests shall be performed without adjustment of the attenuators, the readings being observed directly from the instrument scale, and also with the attenuators adjusted for each burst duration in order to maintain the reading as nearly constant at 80 percent of full scale as the attenuator steps will permit.

Unless otherwise specified, measurements shall be made through the weighting network.

B-2.2 Dynamic Characteristic in Response to Repetitive Tone-Bursts

B-2.2.1 *Methods of Measurement*

A series of 5 ms bursts of 5 kHz tone starting at zero-crossing is applied to the input at an

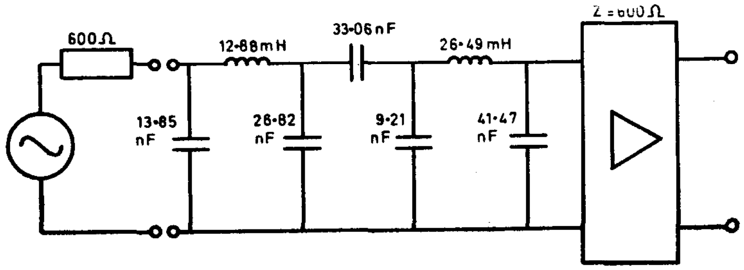


FIG. 13 WEIGHTING NETWORK

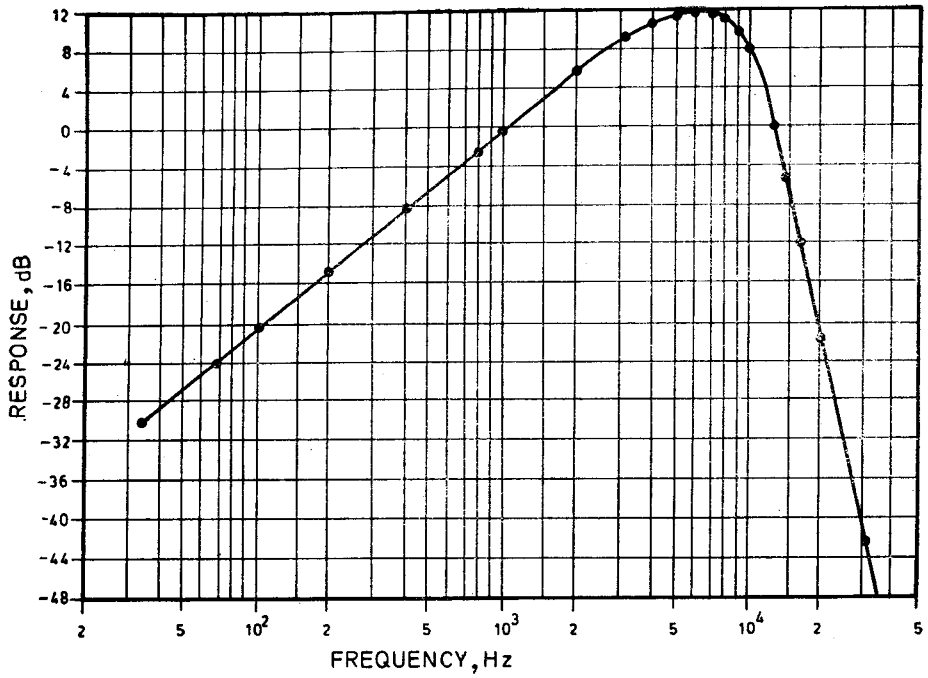


FIG. 14 FREQUENCY RESPONSE OF THE WEIGHTING NETWORK SHOWN IN FIG. 13

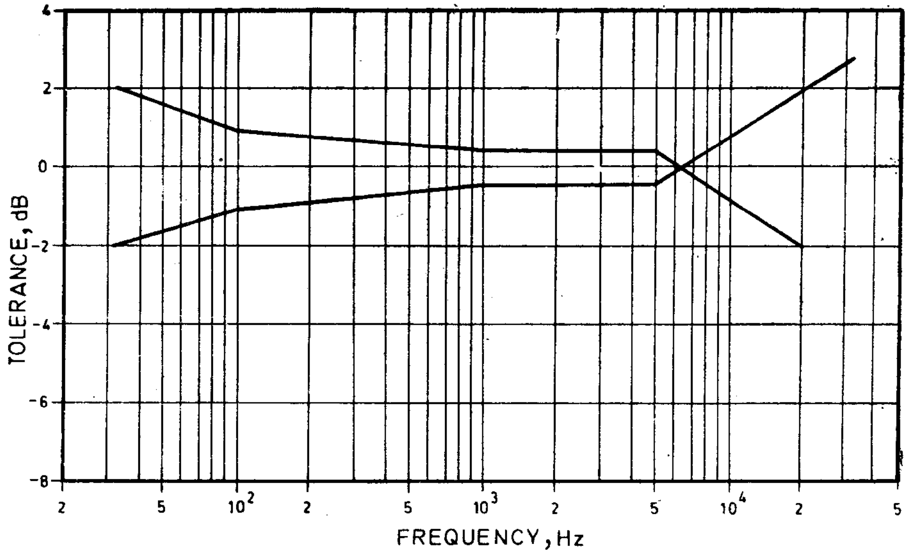


FIG. 15 MAXIMUM TOLERANCES FOR THE FREQUENCY RESPONSE OF THE WEIGHTING NETWORK VALUE

Table 5 Time Response Characteristic of the Measuring Set

(*Clauses* B-2.0 *and* B-2.1)

Burst duration (ms)		1*	2*	5	10	20	50	100	200
Amplitude reference steady signal reading	(%)	17·0	26·6	40	48	52	59	68	80
	(dB)	—15·4	—11·5	—8·0	—6·4	—5·7	—4·6	—3·3	—1·9
Limiting values :									
— lower limit	(%)	13·5	22.4	34	41	44	50	58	68
	(dB)	—17·4	—13·0	– 9·3	—7·7	—7·1	—6·0	—4·7	—3·3
— upper limit	(%)	21·4	31·6	46	55	60	68	78	92
	(dB)	—13·4	—10·0	—6·6	—5·2	– 4·4	—3·3	—2·2	—0·7

*The use of burst durations less than 5 ms is not mandatory.

amplitude such that the steady signal would give a reading of 80 percent of full scale. The limits of the reading corresponding to each repetition frequency are given in Table 6.

The tests shall be performed without adjustment of the attenuators but the characteristic shall be within tolerance on all ranges.

Table 6 Dynamic Characteristic in Response to Repetitive Tone-Bursts

(*Clause* B-2.2)

Number of bursts per second		2	10	100
Amplitude reference steady signal reading	(%)	48	77	97
	(dB)	−6·4	−2·3	−0·25
Limiting values:				
—lower limit	(%)	43	72	94
	(dB)	−7·3	−2·9	−0·5
– upper limit	(%)	53	82	100
	(dB)	−5·5	−1·7	−0·0

B-2.3 Overload Characteristics

The overload capacity of the measuring set shall be more than 20 dB with respect to the maximum indication of the scale at all settings of the attenuators. The term 'overload capacity' refers both to absence of clipping in linear stages and to retention of the law of any logarithmic or similar stage which may be incorporated.

B-2.3.1 *Method of Measurement*

Isolated 5 kHz tone bursts of the 0·6 ms duration starting at zero-crossing are applied to the input at an amplitude giving full scale reading using the most sensitive range of the instrument. The amplitude of the tone-bursts is decreased in steps by a total of 20 dB while the reading are observed to check that they decrease by corresponding steps within an overall tolerance of ± 1 dB. The test is repeated for each range.

B-2.4 Reversibility Error

The difference in reading when the polarity of an assymmetrical signal is in reverse shall be not greater than 0·5 dB.

B-2.4.1 *Method of Measurement*

Rectangular dc pulses 1 ms with a pulse repetition rate of 100 pulses per second or less are applied to the input in the unweighted mode, at an amplitude giving an indication of 80 percent of full scale. The polarity of the input signal is reversed and the difference in indication is noted.

B-2.5 Overswing

The reading device shall be free from excessive overswing.

B-2.5.1 *Method of Measurement*

One-kilohertz tone is applied to the input at an amplitude giving a steady reading of 0·775 V of 0 dB. When this signal is suddenly applied there shall be less than 0·3 dB momentary over reading.

B-2.6 Calibration

The instrument shall be calibrated such that a steady input signal of 1 kHz sine-wave at 0·775 V rms, having less than 1 percent total harmonic distortion shall give a reading of 0·775 V (0 dB). The scale shall have a calibrated range of at least 20 dB with the indication corresponding to 0·775 V (0 dB) between 2 and 10 dB below full scale.

B-2.7 Input Impedance

The instrument shall have an input impedance $\geqslant$ 20 kΩ and if an input termination is provided then this shall be 600 Ω ± 1 percent.

ANNEX C

CALIBRATION OF THE ALTERNATING LOW-FREQUENCY MAGNETIC FIELD STRENGTH

C-1 MEASURING THE MAGNETIC FIELD STRENGTH

For measuring the magnetic field strength, the use of a search coil, according to Fig. 16 is recommended, which will produce an emf of 1 mV in a magnetic field with a strength of 1 A/m at a frequency of 50 Hz, the voltage being proportional to both the magnetic field strength and the frequency.

The search coil output voltage should also be measured with the magnetic field switched off. If the output voltage under these conditions exceeds one-third of the output voltage with the field present, a selective measurement is required. If possible, the search coil output voltage should be measured using a voltmeter with balanced input.

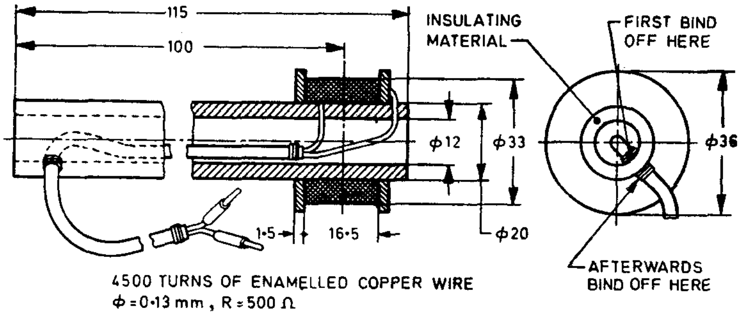


FIG. 16 SEARCH COIL FOR MEASURING THE MAGNETIC FIELD STRENGTH

ANNEX D

(*Clause* 23.1)

MEASUREMENT OF RF MAGNETIC FIELDS GENERATED FOR THE INJECTION OF SIGNALS INTO RECEIVERS WITH MAGNETIC ANTENNAS

D-1 RESONANCE METHOD OF MEASUREMENT

D-1.1 The measurement is carried out by placing a shielded air-core loop aerial at the chosen measuring position. A variable capacitor is used in conjunction with a shielded coil in series with the loop, to achieve resonance at the relevant frequency, as indicated by a radio-frequency voltmeter connected to the terminals of the capacitor (*see* Fig. 17).

The field strength E is expressed as:

$$E = \frac{\lambda U_{\text{res}}}{2\pi ANQ}\ \mu\text{V/m} = \frac{150\, U_{\text{res}}}{\pi f\, ANQ}\ \mu\text{V/m}$$

where

λ = wavelength corresponding to the relevant frequency, expressed in metres,

U_{res} = radio-frequency voltage at resonance, in microvolts,

A = area of the measuring loops in square metres calculated from it means diameter,

N = number of turns of the measuring loop, and

Q = voltage magnification of the measuring circuit.

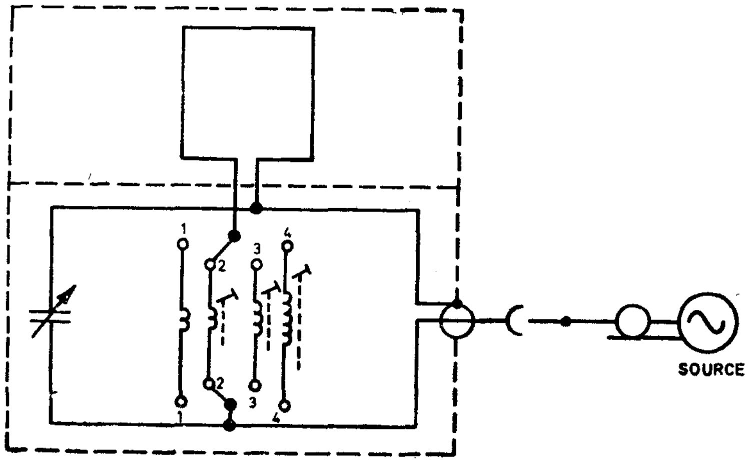


FIG. 17 CIRCUIT ARRANGEMENT OF SCREENED LOOP

The value of Q shall be determined for each frequency, according to standard practice.

D-2 APERIODIC METHOD OF MEASUREMENT

D-2.1 Alternatively, an aperiodic method of measurement may be applied. In this case, an untuned loop, anti-resonance of which is at a much higher frequency than the measuring frequency, can be used in conjunction with a voltmeter of sufficiently high impedance.

In this case, the field strength is expressed as:

$$E = \frac{\lambda U}{2\pi AN}\ \mu\text{V/m} = \frac{150\,U}{\pi f AN}\ \mu\text{V/m}$$

where

U = voltage in microvolts.

D-3 CONSTRUCTION OF A MEASURING LOOP

D-3.1 A shielded air-core loop antenna for measuring RF magnetic fields, consists of a special screened square single turn loop with a surface area of 0·01 m^2. The screening of this loop is formed by sheets of low-loss material containing printed conductors consisting of small strips. Its construction is shown in Fig. 18 At the lower sides of the sheets, the strips are interconnected and in contact with the metal box containing the rest of the tuned circuit. At their upper ends, the strips are not interconnected, but those of the front sheet and the back sheet of the screen are soldered to short strips printed on the top sheet; there strips are not interconnected and, being broken at their centres, do not connect the strips of the front sheet with those of the back sheet.

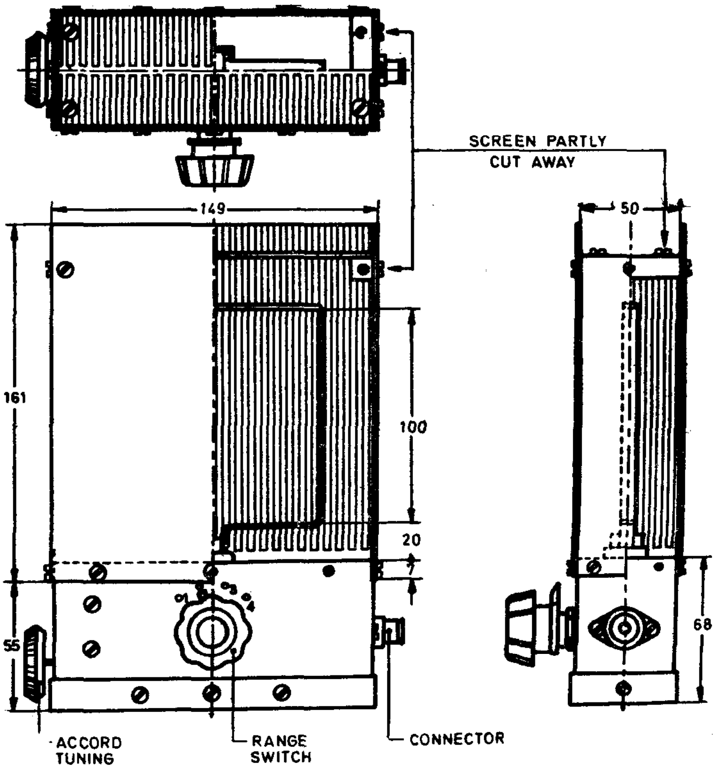
NOTE — This special form was developed because available commercial coils, give rise to incorrect minima due to the presence of electric fields.

The loop, when used for checking the field strength, forms part of the tuned circuit with a variable capacitor and set of coils, the appropriate one for the wanted frequency range being inserted into the circuit by a double-pole switch (*see* Fig. 17).

For the sake of clarity, the fact that all coils are short-circuited when not in use is not shown in the diagram.

Four positions of the switch cover the total frequency range of approximately 150 kHz to 37 MHz.

NOTE — A similar loop, but without switch and tuned circuits, can be used to generate a magnetic field.



All dimensions in millimetres.

FIG. 18 SCREENED LOOP FOR MEASUREMENT OF MAGNETIC FIELDS CONSTRUCTION

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards on 26 June 1989, after the draft finalized by Radio Communications Sectional Committee had been approved by Electronics and Telecommunication Division Council.

This Standard (Part 1) deals with the determination of performance, the comparison of equipment and the determination of proper practical applications by listing the characteristics which are useful for specifications and laying down uniform methods of measurement for these characteristics.

This standard is confined to a description of the different characteristics and the relevant methods of measurement; it does not in general specify performance requirements.

The methods of measurements on AM and FM radio receivers were earlier covered by IS 614 : 1964 and IS 2731: 1964 based on IEC Pub 69 (1954) 'Recommended methods of measurement on receivers for amplitude modulation broadcast transmission' and IEC Pub 91-1958 'Recommended methods of measurement on receivers for frequency-modulation broadcast transmissions,' respectively. At international level it has now been decided to bring out a series of publications covering methods of tests for sound broadcast receivers under IEC Pub 315 superseding IEC Pub 69 and IEC Pub 91. Consequently at national level it is proposed to follow the IEC trends and develop a series of standards based on the latest IEC Publication. As such this series of standards is being brought out and this shall supersede IS 614 : 1964 and IS 2731 : 1964.

This standard forms Part 1 of a series of standards on methods of tests on radio receivers. Other parts prepared so far in this series are:

Part 2 RF measurements on receivers for amplitude-modulated sound broadcast emissions

Part 3 RF measurements on receivers for frequency-modulated sound broadcast emissions.

This standard does not include the methods of tests for safety requirements which are covered by IS 616 : 1986 nor with radiation which is covered in IS 4546 : 1983.

This standard is based on IEC Pub 315-1 (1988) 'Methods of measurement on radio receivers for various classes of emissions, Part 1 General considerations and methods of measurements including audio-frequency measurements', issued by the International Electrotechnical Commission (IEC).

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